The Development of Entrepreneurial Thinking in STEM Education: A Teaching and Learning Module for Elementary Students

Nyet Moi Siew and Jamilah Ahmad
Universiti Malaysia Sabah, Kota Kinabalu, Malaysia
sopiah@ums.edu.my
jamilahahmad99@gmail.com

Abstract: The development of modules in cultivating entrepreneurial thinking (ET) in Science, Technology, Engineering, and Mathematics (STEM) education at the elementary school level is still limited. Thus, this research was conducted to establish the feasibility of the teaching and learning (TL) module based on the socioscientific issues approach aided by the thinking wheel map (SIA-TM). A case study was conducted among 30 fifth graders in the first phase of the module evaluation. Data was collected via respondents' feedback in the 5-point Likert scale questionnaire and focused groups interviews. The students showed a high level of acceptance (m=4.53) towards the activities in the SIA-TM TL Module. Students opined that the SIA-TM TL module assisted them in developing new ideas and a responsible attitude towards their community. The second phase was evaluation through the quasi-experimental research design with the pre-test- post-test control group design. A total of 60 fifth graders were gathered into two intervention groups which were the SIA-TM group (n=30) and the control group (n=30). The results of the t-test prove a significantly positive effect of the SIA-TM TL Module on the five constructs of ET. Therefore, these findings establish that the SIA-TM TL module is feasible in promoting fifth graders' ET in STEM education.

Keywords: socioscientific issues approach, thinking wheel map, entrepreneurial thinking, STEM education

1. Introduction

Entrepreneurial thinking (ET)h as gained attention in the science curriculum due to the need for developing individuals who can think critically, creatively, innovatively, and inhibit high values. Entrepreneurial thinking is recognised as one of the most relevant thinking skills students should master to face an increasingly challenging future (Bacigalupo et al, 2016; Buang et al, 2009). This skill is not merely to become an entrepreneur but is an intrinsic skill that is important for establishing human development, fulfilling the market's demands and increasing competition (Bacigalupo et al, 2016).

According to Buang et al (2009), ET is not just a concept that brings about entrepreneurs, but it is a design-thinking skill based on scientific knowledge and entrepreneurial orientation. Buang et al state that designing a model requires students to master five important ET constructs: observation, new ideas, innovation, creativity, and values. The mastery of these constructs aids students in generating ideas, choosing ideas, sketching designs, creating models and evaluating the contribution of their design to society.

Similar to other countries, Malaysia is now preparing school students for global needs. In its Elementary School Standard Curriculum 2017 edition, the element of the entrepreneurial curriculum has been applied in all subjects, including Science. The module that is supposedly used to inculcate ET in STEM education at the elementary school level is very limited. In comparison, Karlsson et al (2021) stated that emphasis on innovation and entrepreneurship is incredibly significant to face the 21st century. Thus, a learning concept which integrates STEM, innovation and entrepreneurship in the school curriculum needs to be introduced for students to become designers, innovators and possess entrepreneurial values. In fact, emphasis on the entrepreneurial element in STEM education is another effort to attract students' interest in STEM subjects besides studying the ways of commercialising ideas with the integration of various fields of study.

Since there are gaps and issues in implementing ET in science curriculum, a teaching and learning (TL) module based on socioscientific issues approaches (SIA) aided by a thinking wheel map (TM) is developed, and its feasibility in promoting ET in STEM education is determined.

2. Theoretical framework

The design and development of the SIA-TM TL module based on the analysis of various elements was proposed, such as the application of the SIA, the use of a TM, the implementation of STEM education in elementary schools, understanding towards the learning styles of elementary school students and its relation to theories and teaching models. The SIA-TM TL module applied the concept of knowledge construction by adapting to the environment following Piaget's theory of cognitive constructivism (1976) and Vygotsky's theory of social constructivism (Vygotsky, 1978). Piaget's theory is compatible with fifth graders in this research as it focuses on the concept of using their prior knowledge to analyse socioscientific issues and design products that can solve issues presented to them. Through the discussions and solutions to socioscientific issues, students would undergo a process of exploration and recognise their prior knowledge. The impact of this is a balance between the assimilation and accommodation processes toward new information based on their existing knowledge (Sjøberg, 2007).

In line with the students' ages (10-11 years old), Piaget's theory of cognitive constructivism states that these children are within the concrete operational stage where they are able to investigate and solve concrete problems rationally (Pascual-Leone & Johnson, 2005). Therefore, in this research, students were presented with stimulating material such as socioscientific issues and pictorials suitable for their cognitive stage. Additionally, in line with Vygotsky's theory of social constructivism, students were assigned into small groups to enable teamwork activities and the generation of ideas. Indirectly, discussion activities in these small groups applied the social aspect to the students' learning process (Jones & Brader-Araje, 2002).

Researchers realise the importance of pedagogical principles in the process of TL in elementary schools to support the process of information and knowledge construction cognitively and socially. This research applied the ET model (Buang et al, 2009), SIA (Sadler et al, 2017) and TM (Bloom, 1956; Glenn, 1972; Bengston, 2016) in the module development.

The SIA was used because of its suitability in terms of psychological, social and emotional growth for children as well as its usability in various aspects of science education (Zeidler & Nichols, 2009). Teachers who use SIA in learning sessions help students develop and evaluate arguments related to current issues (Owens et al, 2017). The first phase is focused on the issue at hand. Students build their understanding by relating issues with scientific ideas and community awareness in this phase. The second phase prepares a platform for teachers to encourage their students to understand and practice science that stresses socioscientific and community issues. In this way, students will be actively involved in searching for relations between social issues and scientific knowledge and practices that boost the relevance of the issues to be solved (Sadler et al, 2017). The last phase encourages students to synthesise ideas and practices. This phase provides students opportunities to be actively involved in manifesting ideas and opinions ethically.

The SIA has become the chosen approach to solve scientific, technological and community issues in the research of Birmingham and Barton (2014) and Nam and Chen (2017). SIA is observed to help increase students' scientific knowledge (Driver et al, 2000; Kinslow & Sadler, 2018; Sadler et al, 2017; Topçu et al, 2018). Scientific knowledge generated through socioscientific debates will drive students to produce ideas effectively because they have to relate the contributions of their inventions to real issues in society.

The TM was adapted from Bloom (1956), Glenn (1972) and Bengston (2016). The TM consists of a circle in the centre and five cycles which could help students to produce and organise their ideas. When using the SIA-TM TL module, the students were given socioscientific issues for discussion and debate. Any logical and scientific ideas will be written onto the centre of the map. These scientific ideas will trigger students to contribute ideas in the next cycle. Bengston (2016) stated that the TM is easily understood by students and stimulates their systematic thinking. This statement is compatible with this study's application, where students needed to generate ideas in groups through brainstorming sessions. Any logical and feasible idea will be entered into each cycle. Moreover, the TM aids students in collecting ideas speedily.

To merge the SIA with the TM, the researchers used the method of thorough integration (Swartz & Parks, 1994). With this method, the ET skill is taught together with the lesson's contents. The thorough integration was taught in five steps, that is: (i) introduction, (ii) thinking actively, (iii) thinking about thinking, (iv) reinforcement exercise, and (v) thinking application. In this case, two components (learning content and ET skill) are implemented as complementary in each step of the process.

In developing the unit activity in the TL module, the researchers applied the ET model which was divided into five steps that are i) plan and do purposeful observation [Observation], ii) create ideas by looking for uniqueness or strengths [New Ideas], iii) choose ideas that can be modified or improved and evaluate those ideas

[Innovation], iv) strengthen and improve good ideas in a focused manner [Creativity], and v) ensure that ideas or products are meaningful for society [Value].

The ADDIE Model (Branch, 2010), which consists of five phases that are analysis, design, development, implementation and evaluation, was adopted in the design and development of the SIA-TM TL module. The ADDIE Model was selected because it focuses on student-centred learning, its learning design is goal-oriented, and it enables students to show meaningful actions and solve issues practically. The theoretical framework for the design and development of the SIA-TM TL module is shown in Figure 1.

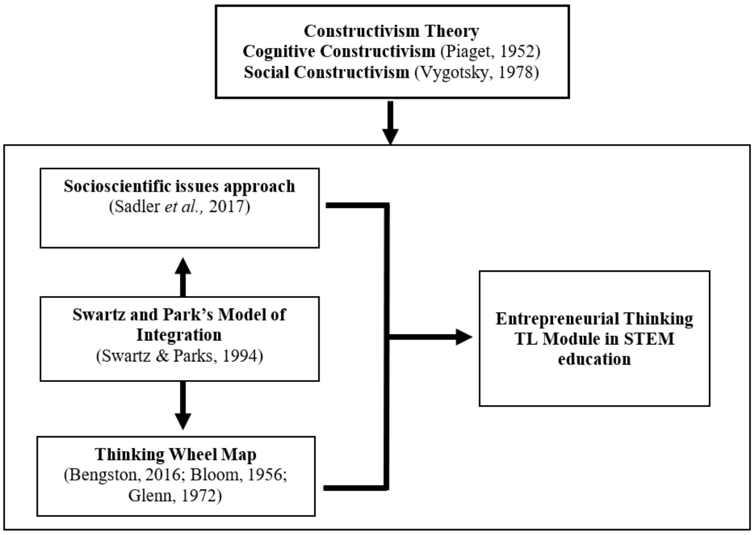

Figure 1: Theoretical framework for the design and development of SIA-TM TL module

3. Purpose and research questions

This research was conducted to design and develop a TL module that integrated the SIA and TM to inculcate ET in STEM education among fifth graders. There are three research questions that drive this study: -

- 1. How feasible is the SIA-TM TL Module for fifth graders?
- 2. How do the fifth graders make sense of their experience in constructing ET?
- 3. How effective is the SIA-TIM TL module in promoting ET?

4. Research methodology

4.1 Research design and sample

This research employed a descriptive and quasi-experimental research design. The descriptive research design involved 30 fifth graders in a case study that assessed the aspect of the feasibility of the SIA-TM TL module and explored fifth graders' experience in the construction of ET. In contrast, the quasi-experimental research design was employed to assess the effects of the SIA-TM TL module on the fifth graders' ET in STEM education. This research was conducted over 12 weeks, beginning from September to November 2020.

4.2 Ethical considerations

The researchers obtained consent from the headteachers, teachers and students. The students were provided letters of agreement for their parent's approval for their involvement in the research. All the respondents were informed about the confidential nature of the research and that they could pull out of the research without facing any punishment.

4.3 Descriptive research

4.3.1 Analysis phase

The main purpose of the SIA-TM TL module design was to encourage and inculcate ET among fifth graders in STEM education that is taught in the science subject. To achieve the objectives of this research, researchers conducted an analysis. This analysis is about the needs of the students and the context of the study. The researchers interviewed a group of 30 fifth graders from one elementary school in Tawau, Sabah. The focus group interviews were conducted in a group of five, each lasting 30 minutes from 5 – 7 July 2020.

In the analysis of students and context, the criteria were adapted from Carlton et al (2000) that focused on the unit of students' low achievement level, student's prior knowledge about Physical Science and Technology and Sustainable Life themes, sketching skills, creation skills and peer pressure. The analysis showed that students were unanimous in their opinions on all the aspects except for prior knowledge about Physical Science and Technology and Sustainable Life themes, which they considered weak. Therefore, the teaching process will be adapted to the fifth-graders level and needs as best as possible.

4.3.2 Design and development of SIA-TM TL module

The SIA-TM TL Module was developed by adapting the SIA that introduces social issues to students, which helps them study the social and scientific components of those issues and encourages them to generate solutions that are based on societal values. The TM was provided as a thinking tool to help the students solve socioscientific issues given to them. The SIA and TM was integrated through Swartz and Parks' (1994) integrated thinking model.

The module has six STEM activity units covering Physical Science and Technology and Sustainable Life themes as found in the latest edition of the Year Five Science Curriculum and Assessment Standard Documents (Curriculum Development Division, 2019). Every activity was allocated 180 minutes. However, this time suggestions for the activity implementation can be customised according to the TL in school, as this module can be executed outside TL hours.

In the observation step, students were instructed to make planned and purposeful observations. Students were provided with stimulus pictures that showcased the product designs nowadays. Then, students were asked to make observations to garner information on the building materials, design and product characteristics. Next, students were tasked with thinking ideas to look for uniqueness and strengths. This step encouraged students to search for the uniqueness and strengths of the building materials, design and product characteristics in the product they had observed. The innovative step refers to the students' activity of selecting several ideas that can be modified or improved and observing those ideas. The selection of ideas that can be improved helped the students to create a product design in the future. Students then had to evaluate those ideas by stating their reasons for choosing them. As for the creative step, this activity is to strengthen and increase ideas in a focused manner based on the previously chosen ideas. Students upgraded their ideas by making sketches, labelling and building the product design model. Next, students had to determine the product's name, offer price and the target group of buyers.

Lastly, the value step was for the students to ensure that their ideas or product was useful to society. Students stated their products' advantages to society. They could state the product's strengths in terms of its cost-saving qualities, product functions and properties, and ethics involved in the creation of the product. This step was to inculcate values such as love for the environment and the practice of using sustainable materials in creating a product for society. The students then had to present their creations in class and explain the benefits of their products.

According to the TM cycle, all these steps were carried out in stages. These five steps involved different student activities. To gain maximum effect, the activities in this module were executed in groups to ensure the exchange of ideas and the search for creative and innovative solutions. The teachers' instructions and guidance were needed in this module's implementation. Table 1 shows the integration of the SIA and TM in developing the ET TL module.

4.3.3 Evaluation phase

Taherdoost (2016) stated that a module's content must be verified before it can be applied. The first evaluation phase evaluated the module's feasibility and respondents' acceptance. This phase was conducted after the SIA-TM TL Module was shared with the 30 fifth-graders through the process of TL.

A questionnaire was distributed to the respondents to gather their perceptions about the feasibility of activities proposed in the SIA-TM TL module. The questionnaire used the Likert Scale with the value of 1 (strongly disagree) to 5 (strongly agree). As many as 11 questions were adapted from Rahman (2020), which required students to provide their feedback from the aspect of feelings, benefits from the execution of the five-step ET, the use of the SIA and TM. The questionnaires were given to fifth-graders as soon as the module's intervention was conducted.

The closing phase (evaluation phase) was done via interviews in focused groups to gain students' feedback about the implementation of the SIA-TM module. After using the SIA-TM module, they were asked to share their feelings and experiences and elaborate on how the module's use could impact them.

Table 1: Integration of SIA approach and TM in the ET TL module

Socioscientific Issues Approaches (SIA)	**Thinking Wheel Map (TM)**	**Integration of SIA and TM in the ET TL Module**
Phase 1 Students discover or are introduced to an issue	**First Cycle - Observation** Planned and purposeful observation	**Introduction** The teacher introduces a socioscientific issue to students and instructs students to make an observation of an issue in the first cycle of the TM.
Phase 2 Students study the social and scientific components related to issues in the first phase.	**Second Cycle – New Ideas** Create ideas by looking for uniqueness or strengths in a product observable in building materials, design, and product characteristics.	**Think actively** Socioscientific issues and stimulus materials are used to guide students to generate ideas by finding uniqueness or advantages through the second cycle of TM.
	Third Cycle – Innovation Selection of several ideas that can be modified or improved and evaluate those ideas	**Thinking about Thinking** Students are stimulated to choose several ideas that can be modified or improved and evaluate those ideas through the third cycle in the TM to solve the presented issues.
Phase 3 Students make an effort to generate a solution based on societal values.	**Fourth Cycle – Creativity** Strengthen and improve in a focused manner	**Consolidation Practice** Students strengthen and improve the ideas they have chosen in a focused manner in the fourth cycle of the TM and sketch their ideas for the product.
	Fifth Cycle – Value Ensure that the idea or product that is created is meaningful for society.	**Applying Thinking** Students state and ensure that the characteristics of their products are useful to society and can solve the issues presented in the fifth cycle of the TM.

4.4 Quasi experimental research

The execution phase of the experimental research involved the implementation of the SIA-TM TL module and evaluating its effectiveness in the classroom session. In line with this, the control group pre-test – post-test quasi-experimental research design was employed. A total of 60 students were chosen randomly from one elementary school in the Tawau district and were placed into two groups; the treatment group (SIA-TM, n=30) and the control group (GC, n=30). The respondents in the treatment group received the SIA-TM module that comprised six learning units for 12 weeks from October to December 2020. Each unit required the implementation time of 180 minutes with three missions to be solved; Mission 1: Discussion of socioscientific issues, Mission 2: Discussion of model design, and Mission 3: Presentation of the model design. These three missions could be conducted in three stages according to the suitability of the school's TL timetable. The respondents in the control group were exposed to the method of designing a conventional design without using the socioscientific issues approach and thinking wheel map.

To evaluate the module's effectiveness, the ET Test (ETT) (Ahmad & Siew, 2021) that the researchers designed was used. This instrument was proven valid, reliable, and suitable for evaluating fifth-graders ET. The ETT covered 10 items that required students to answer questions in the form of statements and idea sketches. The questions were constructed based on the five constructs in ET (Buang et al, 2009), which were referred to the Curriculum and Assessment Standard Document (CASD) Grade Five Science learning contents under the Physical Science and Technology and Sustainable Life themes (Curriculum Development Division, 2019: 61-79). The main question asked students to create a handphone design to be used by future society. The context of using handphones was chosen because it is contained in the CASD under the Physical Science theme. Students were then provided with a stimulus picture, and 10 questions arranged according to the cluster construct to enable them to organise their answers and get the desired results. The ETT scoring was done based on the scoring of Ho et al (2013). Each item prepared for this test carried a minimum score of zero and the maximum score of three.

4.5 Data analysis

The quantitative data was analysed by calculating the percentage and mean. The analysis of the interview questions for the focused group was done using thematic analysis (Braun & Clarke, 2006) by deriving themes from the interviews about the experiences gained by the 30 fifth-graders after using the SIA-TM TL module. The researchers analysed the interview data thoroughly, gained the pattern linkage from the respondents' experiences, and explained the respondents' experiences in the construction of ET (Fereday & Muir-Cochrane, 2006).

5. Research findings

5.1 Students' Perception towards the Module

5.1.1 Findings from questionnaire

The students' perceptions of the feasibility of the module were collected via the questionnaire given to the respondents. The overall mean of 4.53 showed that the SIA-TM TL module had a high value of acceptance and feasibility. 30% of the respondents agreed, while 63% strongly agreed with the SIA-TM TL module's feasibility. A minimum mean of 3.50 shows that the feasibility aspect of the module is acceptable (Junus et al, 2021). The research findings between 4.06 to 4.86 proved that the SIA-TM TL module was feasible in fostering ET among fifth-graders.

5.1.2 Interviews with the focused group

Several themes were identified based on the respondents' views in the focused group interviews regarding the implementation of the SIA-TM TL module. The findings are as follows:

Arrangement of ideas and expansion of new ideas. The use of the SIA-TM TL module helped students arrange their ideas in a more organised way and expanded their new ideas.

> *"...When we were asked to write on the wheel, I told myself, why must we use a wheel? Can't we just create the product directly? But when we did it, the ideas came one by one, then (I realised) the importance of the wheel. If there were no wheel, it would be difficult to arrange ideas ..." (S2)*

> *"... ideas could be arranged easily. We could create a product more systematically..." (S14)*

Increase in STEM knowledge. Students also stated that the SIA-TM TL module increased their STEM knowledge.

> *"... I did not realise that this wheel map could help me to get to know and learn what is in STEM..." (S11)*

> *"...At first, I asked myself what STEM is. After writing on the wheel map, then I understood that we had to produce products that used the knowledge of science, technology, engineering and mathematical..." (S13)*

Excitement when creating a prototype. Students expressed their excitement and thrill when creating their prototypes.

> *"We created a car that used water because the use of fossil fuels is not good for the environment. I feel this was very fun because the map helped us to create the car. We arranged our ideas one by one until the car was created ..." (S10)*
>
> *"...I am impressed with myself. Our group did not expect to create a product for the future. I am really, really happy..." (S12)*

Inculcates the value of helping the community in the future. The SIA-TM TL module proved to help students cultivate a feeling of responsibility to solve universal issues to help future society.

> *"...At first, we were given issues to discuss. I also did not know that our world is facing the issues that our teacher showed us. So in the wheel, we wrote the issues that we discussed, and then we wrote ideas to create a product. The wheel really helps the future society..." (S7)*
>
> *"... at first, I was scared that this project would not work out ... But when it was done as a group ... we could create a product that we wanted for the future community" (S9)*

Increase curiosity. The students' curiosity was also increased through this innovative SIA-TM TL module.

> *"... during the creation of our product, we asked each other questions in our group. Because we want to know what would happen if we did something like this? We wanted to know the outcome..." (S13)*
>
> *"... actually, we were afraid that our plan would not work out. But after writing ideas on the map, we did what was planned, and it was materialised. Of course. Because we already wrote ideas, we were impatient to know what would happen next..." (S2)*

Encourages teamwork in a group. The value of teamwork and unity in a group could be brought out through the innovative SIA-TM TL module.

> *"... the wheel map helps me to collaborate with my friends in creating our group project..." (S4)*
>
> *"...I feel that all our work became easy. Because the wheel was done together, we discussed together to get ideas. Finally, we succeeded..." (S6)*

5.2 Effectiveness of the SIA-TM TL module

5.2.1 Independent sample T-Test (ISTT)

ISTT was conducted to compare the pre-test mean score for the five constructs between the SIA-TM and CG. Analysis results (Table 2) indicated that there were no significant differences between the pre-test mean scores between SIA-TM and CG in the Observation, New Ideas, Innovation, Creativity and Value constructs with each construct's value at ($t(58) = .408$, $p > .05$; $t(58) = –.188$, $p > .05$; $t(58) = –.166$, $p > .05$; $t(58) = –.184$, $p > .05$; $t(58) = 0.00$, $p > .05$).

Gay and Airasian (2003) stated that if there were no significant differences for the mean scores between the two pre-tests, then the T-Test could be conducted on the post-test mean score. Thus, the ISTT could be carried out to compare the SIA-TM and the CG mean scores in the five constructs of ET. The analytical results show that the respondents in the SIA-TM group had a significant higher score compared to the control group from the aspect of Observation, New Ideas, Innovation, Creativity and Value constructs with each value at ($t(58) = 8.748$, $p < .05$; $t(58) = 7.906$, $p < .05$; $t(8) = 8.700$, $p < .05$; $t(58) = 8.106$, $p < .05$; $t(58) = 8.887$, $p < .05$). These results proved that there was a significant difference in the post-test for students from the SIA-TM group compared to those in the CG in the five constructs of ET.

Table 2: Results of ISTT analysis

Construct	Test	SIA-TM Group (Mean)	Control Group (Mean)	Group Difference	*t*	*df*	*P*
Observation	Pre	2.37	2.30	.067	.408	58	p> .05
	Post	4.93	3.57	1.367	8.748	58	p< .05
New Ideas	Pre	2.23	2.27	-.033	-.188	58	p> .05
	Post	4.97	3.40	1.567	7.906	58	p< .05
Innovation	Pre	2.47	2.50	-.033	-.166	58	p> .05

Construct	Test	SIA-TM Group (Mean)	Control Group (Mean)	Group Difference	*t*	*df*	*P*
	Post	5.07	3.33	1.733	8.700	58	p< .05
Creativity	Pre	2.57	2.60	-0.33	-.184	58	p> .05
	Post	5.17	3.63	1.533	8.106	58	p< .05
Value	Pre	2.40	2.40	0.00	0.00	58	p> .05
	Post	5.10	3.50	1.600	8.887	58	p< .05

Note: Significance level at p=.05

6. Discussion

Overall, the findings have proven that the SIA-TM TL module is feasible in fostering fifth-graders ET. This research demonstrated that the socioscientific issues approach, thinking wheel map, Swartz and Park's integration model, ET model and ADDIE's instructional design model were able to produce a SIA-TM TL module which is feasible in STEM education. The interview findings proved that the use of the SIA-TM TL module assisted students in organising ideas and expanding new ideas more effectively, as well as increased their STEM knowledge. Students were also discovered to have enjoyed making the prototype and were more curious throughout the SIA-TM learning experience. In fact, the students also developed an awareness and responsible attitude towards their future community and teamwork in their respective teams.

The independent sample t-test showed that fifth-graders in the SIA-TM displayed significantly better performance in the five constructs of ET in the post-test compared to the control group. This showed that using the SIA-TM TL module could promote ET more effectively than the control group.

Exposure to the socioscientific issues in the SIA-TM TL module enabled students to make connections between socioscientific issues and their experiences. The discussion of socioscientific issues encourages the beginning of observation and investigation of a phenomenon or situation (Darmaji et al, 2019). The argument made for the socioscientific issues and the observation analysis will encourage students to observe trends and predict situations that have not occurred or have not been witnessed (Syukri et al, 2013). This strengthens the point that the socioscientific issues approach aids students in providing an early visualisation of the product's concept prior to it being created.

Furthermore, exposure to the SIA through the SIA-TM TL module opens up a space for students to expand their knowledge on issues (Khishfe et al, 2017). In this approach, socioscientific issues are put forward in each activity unit and presented together with examples and pictures that show the socioscientific situations occurring at the moment. The introduction to socioscientific issues enables students to make observations based on current situations such as critical pollution. The information brought forward by these issues provides students with input to create products that could solve those socioscientific issues.

The integration of the SIA with the TM also encourages students to note down ideas systematically (Bengston, 2016). Any ideas that are thought of as logical and suitable with the observation, new ideas, innovation, creativity and value constructs about the product are entered into the thinking map's cycles. This facilitates students' endeavours because the cycle concept in the wheel helps them to collect ideas speedily and systematically. The effects of this integration are proven to aid students in mastering the five constructs of ET since the TM is easy to understand and stimulates students' systematic thinking during the brainstorming session in groups (Krueger, 2005).

The SIA aided by the TM also trains students to make decisions about social issues that involve a moral implication in a scientific context (Zeidler et al, 2005). Prior studies (Driver et al, 2000; Sadler, 2004) also agree that socioscientific issues enabled students to study and connect science with daily life and communities. This is in line with the objective of implementing ET in science lessons where students are capable of connecting science with society to create products that are compatible with societal needs and solve socioscientific issues that arise in society.

7. Conclusions

The research confirmed that the SIA-TM TL module is suitable to inculcate entrepreneurial thinking (ET) among fifth-graders. This research highlights the application of the constructivism theory, ET model, socioscientific issues approach, thinking wheel map, Swartz and Park's integration model and ADDIE's instructional design model in creating SIA-TM TL module that is feasible and effective in promoting ET in STEM education. Students not only get to increase their level of ET but also improve their STEM knowledge, expand new ideas, create a sense of enjoyment, sense of teamwork, and a feeling of responsibility to help their community.

References

Ahmad, J., and Siew, N. M. (2021) Development of a children entrepreneurial science thinking test for STEM education. *Journal of Baltic Science Education*, *20*(4), 528–545.

Bacigalupo, M., Kampylis, P., Punie, Y., and Van den Brande, G. (2016) *EntreComp: The entrepreneurship competence framework*. Publications Office of the European Union. https://doi.org/10.2791/593884

Bengston, D. N. (2016) The futures wheel: A method for exploring the implications of social–ecological change. *Society and Natural Resources*, Vol. 29*, No.* 3, pp 374–379. https://doi.org/10.1080/08941920.2015.1054980

Birmingham, D., and Barton, A. C. (2014) Putting on a green carnival: Youth taking educated action on socioscientific issues. *Journal of Research in Science Teaching*, Vol. 51, No. 3, pp 286–314.

Bloom, B. S. (1956). *Taxonomy of educational objectives, Handbook 1: Cognitive domain* (2nd ed.) David McKay Company. https://doi.org/10.1300/J104v03n01_03

Branch, R. M. (2010) *Instructional design: The ADDIE approach*. Springer.

Braun, V., and Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(77),77–101.

Buang, N. A., Halim, L., and Subahan, T. M. M. (2009) Understanding the thinking of scientists entrepreneurs: Implications for science education in Malaysia. *Journal of Turkish Science Education*,Vol. 6*, No.* 2, pp 3–11.

Carlton, D. J., Kicklighter, J. R., Jonnalagadda, S. S., and Shoffner, M. B. (2000) Design develop and formative evaluation for adult program. *Journal of The American Dietetic Association*, Vol. *100, No.*5, pp 555–563.

Curriculum Department Division. (2019) *Dokumen standard kurikulum dan pentaksiran Sains Tahun Lima* [Year Five science curriculum and assessment standard document]. Ministry of Education Malaysia.

Darmaji, Kurniawan, D. A., and Irdianti. (2019) Physics education students' science process skills. *International Journal of Evaluation and Research in Education*, Vol. 8, No. 2, pp 293–298.

Driver, R., Newton, P., and Osborne, J. (2000) Establishing the norms of scientific argumentation in classrooms. *Science Education*, Vol. 84, No. 3, pp 287.

Fereday, J., and Muir-Cochrane, E. (2006) Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme Development. *Interdisciplinary Journal of Qualitative Methods*, *5*(1), 80–92.

Gay, L. R., and Airasian, P. W. (2003). *Educational research: Competencies or analysis and applications*. Prentice Hall.

Glenn, J. (1972) Futurizing teaching vs. futures courses. *Social Science Record*, Vol. 9, No. 3, pp 26–29.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., and Tatham, R. L. (2006) *Multivariate data analysis* (6th ed.). Prentice Hall.

Ho, H.-C., Wang, C.-C., and Cheng, Y.-Y. (2013) Analysis of the scientific imagination process. *Thinking Skills and Creativity*, *10*, 68–78.

Jones, M. G., and Brader-Araje, L. (2002) The impact of constructivism on education: Language, discourse, and meaning. *American Communication Journal*, Vol. 5, No. 3, pp 1–10.

Karlsson, C., Rickardsson, J., & Wincent, J. (2021). Diversity, innovation, and entrepreneurship: Where are we and where should we go in future studies? *Small Business Economics*, *56*(2), 759–772. https://doi.org/10.1007/s11187-019-00267-1

Khishfe, R., Alshaya, F. S., BouJaoude, S., Mansour, N., and Alrudiyan, K. I. (2017) Students' understandings of nature of science and their arguments in the context of four socio-scientific issues. *International Journal of Science Education*, *39*(3), 299–334. https://doi.org/10.1080/09500693.2017.1280741

Kinslow, A. T., and Sadler, T. D. (2018) Making science relevant: Using socio-scientific issues to foster critical thinking. *The Science Teacher*, Vol. 86, No.1, pp 40–45. www.nsta.org/highschool

Krueger, N. F. 2005. The cognitive psychology of entrepreneurship. In Z. J. Acs & D. B. Audretsch (Eds.), *Handbookof entrepreneurship research* (pp. 105–140). Kluster Law International.

Nam, Y., and Chen, Y. C. (2017) Promoting argumentative practice in socio-scientific issues through a science inquiry activity. *Eurasia Journal of Mathematics, Science and Technology Education*, Vol 13, No. 7, pp 3431–3461.

Owens, D. C., Sadler, T. D., and Zeidler, D. L. (2017) Controversial issues in the science classroom. *Phi Delta Kappan*, Vol *99, No.* 4, pp 45–49. https://doi.org/10.1177/0031721717745544

Pascual-Leone, J., and Johnson, J. (2005) A dialectical constructivist view of developmental intelligence. *Handbook of Understanding and Measuring Intelligence*, pp 177–201.

Piaget, J. (1976) Piaget's theory. In *Piaget and His School* (pp. 11–23). https://doi.org/10.1007/978-3-642-46323 5_2

Rahman, M.S.A. (2020) The socio-scientific-based approach helped with future thinking map on the five constructs of students' future thinking*.* Doctoral Thesis, Universiti Malaysia Sabah, Kota Kinabalu, Malaysia

Sadler, T. D. (2004) Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, Vol. *41, No.* 5, pp 513–536. https://doi.org/10.1002/tea.20009

Sadler, T. D., Foulk, J. A., and Friedrichsen, P. J. (2017). Evolution of a module for socio-scientific issue teaching and learning. *International Journal of Education in Mathematics Science and Technology*, *5*(2), 75–87.

Sjøberg, S. (2007) Contructivism and learning. In *International Encyclopaedia of Education* (3rd ed.). Elsevier.

Swartz, R. J., and Parks, S. (1994) *Infusing the teaching of critical and creative thinking into content instruction: A lesson design handbook for the elementary grades*. Critical Thinking Books and Software.

Syukri, M., Halim, L., and Meerah., T.S.M. (2013) *Pendidikan STEM dalam entrepreneurial science thinking "ESciT": Satu perkongsian pengalaman dari UKM untuk Aceh* [STEM education in entrepreneurial science thinking "ESciT": An experience shared from UKM for Aceh]. *Aceh Development International Conference, 2013*, 105–112.

Taherdoost, H. (2016) Validity and reliability of the research instrument; How to test the validation of a questionnaire/survey in a research. *International Journal of Academic Research in Management*, 5(3), 28–36.

Topçu, M. S., Foulk, J. A., Sadler, T. D., Pitiporntapin, S., and Atabey, N. (2018) The classroom observation protocol for socioscientific issue-based instruction: development and implementation of a new research tool. *Research in Science & Technological Education*, Vol 36, *No.* 3, pp 302–323.

Vygotsky, L. (1978) *Mind in society: The development of higher psychological processes*. Harvard University Press.

Zeidler, D. L., Sadler, T. D., Simmons, M. L., and Howes, E. V. (2005). Beyond STS: A research-based framework for socioscientific issues education. *Science Education*, *89*(3), 357–377. https://doi.org/10.1002/sce.20048